

Appl. No. 10/064,620
Amdt. Dated Dec. 20, 2006
Reply to Final Office Action of October 13, 2006

AMENDMENTS TO THE SPECIFICATION:

Please replace the fourth paragraph on page 1 with the following amended paragraph:

In imaging, several techniques for detecting or reconstructing the region of interest exist based on the specific application or use. Typical applications include, for example, medical applications for diagnostic purposes, viewer satisfaction in the case of multimedia applications, or image compression in medical, or satellite applications or other industrial imaging applications like pipeline inspection or inspection, aircraft fuselage inspection. These techniques can be viewed in generic terms as imaging techniques.

Please replace the paragraph that bridges pages 1 and 2 with the following amended paragraph:

Some of the existing image selection techniques include thresholding; edge detection based region identification followed by connected contour analysis; and, morphological operator based algorithms. If the image sequence has ~~two-two~~ dimensional or three-dimensional (2D or 3D, respectively) region-of-interests (ROIs) which can be identified based on ~~the~~ their properties which are significantly different from their surroundings, then many known segmentation based algorithms to extract the ROIs can be used. Again, there are various ways in which segmentation can be done.

Please replace the second paragraph on page 2 with the following amended paragraph:

Two major approaches for segmentation are edge detection and morphological operator methods. In edge detection, in a simplistic setting, a transition in the intensity value is located that is defined as an edge. After this operation has been done on the entire image, the detected edges are classified to be significant or insignificant based on a threshold. Once a final map of the edges is determined and computed, the connected contour analysis follows, wherein the edges that are continuous are located. The region surrounded by the contour is considered as ROI. The same is applicable in 3D also. The morphological operators are unconventional signal processing tools which exploit the geometric properties or characteristics of the signal or an image. There are many "morphological" operators available in the literature like connected operators, watershed transformation, geodesic skeleton, morphological interpolation etc. Connected operators have been successfully used in image segmentation and also for image coding for compression. These operators can be used to reproduce an object (a segmented image that is geometrically closed) which is the ROI.

Please replace the third paragraph on page 2 with the following amended paragraph:

These techniques mostly rely on the complete image for detecting or reconstructing the region of interest and do not look at analytically important regions which can be selected frame by frame. Since the compression is applied on the complete image, it is difficult to achieve higher compression ratios and in cases where lossless compression is applied the compression ratios are low resulting in large computation time and slow transmission.

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In cases where lossy compression can be applied like in industrial imaging applications, there is always a need to improve the compression ratios.

Please replace the last paragraph on page 4 with the following amended paragraph:

Figure 4 illustrates a table for compression ratios for an eight x ray cine angiogram angiogram.

Please replace the paragraph that bridges pages 5 and 6 with the following amended paragraph:

In lossless compression, typically the input image remains intact, but the compression ratios achieved are much lower. Compression technologies used in certain applications, e.g. e.g. medical applications, require a high degree of preciseness and accuracy. No alteration or loss of information is acceptable as their main utilization is for diagnostic purposes. The image compression and decompression method as described above ensures the utilization of the image of interest confined within comparatively small space and time (span of interest). The lossless compression methods described herein focus on this space and time images of interest. This focus has two advantages. The first advantage is achieving higher compression ratios, as the data to be compressed is within a region in the image/video sequences. Higher compression ratios not only result in lesser storage space, but also reduce transmission time for image/video over a network supporting the image processing. The second advantage is of lower complexity of this method. As the compression algorithm works in a smaller region in the image, number of pixels to be dealt with is lesser, and this certainly results in faster decoding (decompression), irrespective of choice of the decoder. The method described described hereinabove addresses faster coding speeds and higher compression ratios simultaneously. Typical compression techniques use transform or prediction based techniques for encoding for example, wavelet transforms, discrete cosine transform (DCT) and other known encoding techniques, then apply entropy coding e.g. e.g. Huffman, Arithmetic or Run length coding to get a compressed bit stream (compressed image sequence).

Please replace the second paragraph on page 8 with the following amended paragraph:

Another embodiment for selecting a portion of the image includes having a user select option for manual or automatic selection of a plurality of frames in a span of interest. In one aspect, the user select option includes segmenting an identifiable anatomy of a patient. Another alternative for the user select option includes manually marking the frames of interest. Yet another alternative of the user select option comprises sketch-gripping an image boundary which is a method where the user roughly outlines the region of interest and the algorithms work at the back end to pull out the relevant image of interest which is within the outlined portion. These user select options can be applied to different imaging techniques like x rays, x ray angiogram, MRI, CT, ultrasound imaging and other non medical imaging techniques. techniques. In a specific example using a MRI system, the selection of a plurality of frames is done using automatic edge detection techniques for selecting the frames of interest in a

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space sequence. In another specific example of using ultrasound imaging, at least one frame in the span of interest includes the selection of a fan shaped image using automatic means or alternately manual means.

Please replace the third paragraph on page 8 with the following amended paragraph:

Figure 2 gives exemplary results of this method of image compression and decompression for eight x ray ciné-angiogram image sequences. The table illustrated in the Figure 2 gives the total number of frames present in the sequence, the first frame (where the contrast agent appears – first time instance) of interest and last frame (where the contrast agent disappears- second time instance, or the last frame in the sequence) of interest, and also the percentage of frames present in the span of interest in time. It is observed that the span of interest in time on an average is 63.55% of the total sequence. This reduces the data set and computations by 36.45%. Hence the effective compression ratio and speed increases by 57.36%.

Please replace the first paragraph on page 9 with the following amended paragraph:

Referring to Figure 3, there is shown an exemplary method for selecting a circular region of interest. As shown, a binary mask that encompasses the circular region in the images is defined. Figure 3(a) shows an original x ray angiogram image, Figure 3(b) shows a binary mask defined image, Figure 3(c) shows a reconstructed image (lossless within the defined shape) and Figure 3(d) shows the information that is not considered for encoding. For x ray ciné-angiograms, the mask is fixed. It is a circular region centered at the middle of the frame and touching the four sides of the image rectangle. Hence, it need not be stored or transmitted separately. In one aspect, the encoding process involves application of a (2,2) integer wavelet transform using lifting scheme with decomposition up to first level. Any integer wavelet may be used for encoding purposes. Wavelet transform provides multi resolution and integer wavelet transform further avoids floating point computation and ensures that the image can be reconstructed back without any error as is known in the art. The wavelet transform, implemented for the circular region is a ROI based wavelet scheme. Wavelet transforms ~~are~~ implemented in the conventional approach using filtering results in floating point (non-integer) values. Coding these coefficients results in rounding-off to the nearest integer, thereby inducing loss in the transmitted images. Hence for lossless coding, characterizing wavelet transforms using lifting scheme that map integers to integers is implemented in this method. ~~method~~. Wavelet transform allows to choose appropriate basis function for the application. The (2,2) and (4,2) interpolating wavelets resulted in low entropy value when applied on ~~for~~ x-ray images. First order entropy of the transform coefficients is calculated that gives the number of bits required to encode the information of interest. The product of entropy and the number of coefficients gives the estimate of the number of bits required, which when divided by the number of bits per frame gives the estimate of the achieved compression ratio (CR). This method of compression would work for any integer wavelet.

Please replace the fourth paragraph on page 10 with the following amended paragraph:

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In yet another exemplary embodiment, an ultrasound imaging device is used for acquiring an imaging sequence 5 of Figure 1, and a binary mask is applied for the ultrasound image under consideration (it is a fan shaped image). For the 480X640 eight bit image, the total number of pixels in the frame is $480 \times 640 = 307200$ and the number of pixels within the mask is 109451 i.e. 35.62% of the full frame. It gives a speed increment of 180%.

Please replace the paragraph that bridges pages 10 and 11 with the following amended paragraph:

While the embodiments described above perform image compression and decompression for 2D/3D images obtained by medical imaging devices, for example x ray, x ray angiogram, MRI, CT, and ultrasound, the embodiments are equally applicable in a four-dimensional (4D) scenario, for example for 4D ultrasound imaging techniques. As used herein, 4D ultrasound imaging acquires images in the x, y, z conventional axes in real time. In the 4D scenario, the volume of the image is considered and the diagnostically important portion of the volume is cropped and stored, such cropped portions are stored over time and it leads to savings in storage space. It is also to be appreciated that embodiments of the present invention are applicable to many other imaging schemes to which compression and decompression are applicable. For example, in satellite imaging, if a certain object is of interest, a central image processing computer can detect the frames which contain ~~contains~~ the target object and keep only that portion of the image in the relevant frames. Employing methods described herein will reduce the compressed file size and hence transmission time from satellite to ground station. Further, methods described herein could be used for defence purposes, weather forecasting, geological imaging for detecting natural resources and other satellite applications. Embodiments of the present invention will also be applicable to industrial imaging applications, for example, fault detection in pipeline inspections and in aircraft fuselage inspections. In case of multimedia applications, video-conferencing or web casting, the same approach can also be used. For example, in news broadcasting, the important image is of the person on the screen. If the background is deleted, it reduces a lot of data and hence can help compression and transmission of such video in a constrained bandwidth environment.